BACK LIGHT UNIT IN LIQUID CRYSTAL DISPLAY

BACKGROUND OF THE INVENTION

The Field of the Invention

This invention relates to a liquid crystal display, and more particularly to a back light unit in the liquid crystal display that minimizes a reflection of the pattern on a wall surface of a light-guide plate and bright lines from a light input.

Description of the Related Arts

Generally, a liquid crystal display (LCD) controls an amount of light transmitted from a back light unit. The transmission is controlled by means of a liquid crystal panel including a number of liquid crystal cells arranged in a matrix and a number of control switches for switching video signals to be applied to the liquid crystal cells, thereby displaying a desired picture on a screen. Conventional back light units will be described with reference to Fig. 1 and Fig. 2 below.

Referring to Fig. 1, the first conventional back light unit includes a light-guide plate 4 for guiding light passing through a light input 20; a reflective plate 2 disposed under the light-guide plate 4 for reflecting light escaping from a lower and side surfaces of the light-guide 4 in an upper direction toward an upper surface of the light guide 4; a first diffusion sheet 6 for diffusing light passing through the light-guide plate 4; first and second prism sheets 8 and 10 for controlling the direction of light passing through

the first diffusion sheet 6; and a second diffusion sheet 12 for diffusing light passing through the prism sheets 8 and 10.

The light input 20 includes a lamp 22 for generating light, and a lamp housing 24 for housing the lamp 22. The lamp housing also reflects the light into the light-guide plate 4. A printed pattern is provided on the lower surface of the light-guide plate 4. This printed pattern does not allow the light-guide plate 4 to exhibit total internal reflection, which would allow light to be uniformly distributed out of the upper surface of the light-guide plate 4.

As mentioned above, the light escaping from the lower surface and the side surface of the light-guide plate 4 are redirected by the reflective plate 2. The light passing through the light-guide plate 4 are diffused into an entire surface area of a liquid crystal panel (not shown) by the first diffusion sheet 6.

The light entering the liquid crystal panel at right angles have a large light efficiency. Thus, it is preferred that the light enter the liquid crystal panel perpendicular to the surface of the liquid crystal panel. Towards this end, two forward prism sheets are disposed to make the angle of the light exiting from the light-guide plate 4 perpendicular to the liquid crystal panel. Referring to Fig. 1, the light passing through the first and second prism sheets 8 and 10 is incident to the liquid crystal panel via the second diffusion sheet 12.

The first conventional back light unit cannot obtain a desired visual angle profile until the two prism sheets are included. The extra prism and the diffusion sheets absorb more light and thus cause an increased loss of light being transmitted to the liquid crystal panel. Also, the manufacturing cost rises.

A suggested structure to solve the above-mentioned problems is shown in Fig. 2. The second conventional back light unit includes a light-guide plate 4' for guiding light passing through a light input 20; a reflective plate 2 disposed under the light-guide plate 4' for reflecting light escaping from a lower and side surfaces of the light-guide 4' in an upper direction toward an upper surface of the light guide 4'; a backward prism sheet 14 for controlling the direction of light passing through the light-guide plate 4'; and a diffusion sheet 12 for diffusing light passing through the prism sheet 14.

The light input 20 and the reflective plate 2 have the same function and operation as those in Fig. 1.

A prism-shaped pattern is provided on the lower surface of the light-guide plate 4'. This prism-shaped pattern does not allow the light-guide plate 4' to exhibit total internal reflection, which would allow the light to be uniformly distributed out of the upper surface of the light-guide plate 4'.

In this case, it is desirable that, since the angle of the light outputted from the light-guide plate 4' is more than about 65°, vertical angles of the prism sheet 14 should be between 63° to 70°. Thus, the light passing through the prism sheet 14 make right angles with respect to the surface of the liquid crystal panel. The light passing through the prism sheets 14 are diffused into the entire surface area of the liquid crystal panel by the diffusion sheet 12.

In the second conventional back light unit, the wall surface of the light-guide plate 4' are reflected and the bright lines of the light input 20 are seen due to the backward prism sheet 14. To solve the problems of the conventional art, a new scheme is needed to reduce the manufacturing cost as well as minimize the wall surface reflection and the bright lines of the light input.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a back light unit in a liquid crystal display that minimizes a reflection of the pattern and wall surface of a light-guide plate as well to reduce bright lines of a light input.

To achieve these and other objects of the invention, a back light unit in a liquid crystal display according to an aspect of the present invention includes a light-guide plate including a pattern of cones to uniformly guide a light passing through a light input; a light-path converter to direct the light such that the light exiting from the light-guide plate is enters a liquid crystal panel perpendicularly to a surface of the liquid crystal panel; and a diffusion sheet for diffusing the light passing through the light-path converter into the liquid crystal panel.

Advantages of the present invention will become more apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects of the invention will be apparent from the following detailed description of the embodiments of the present invention with reference to the accompanying drawings, in which:

Fig. 1 is a sectional view showing the configuration of the first conventional back light unit;

Fig. 2 is a section view showing the configuration of the second conventional back light unit;

Fig. 3 is a section view showing the configuration of a back light unit according to an embodiment of the present invention;

Figs. 4A and 4B are views for explaining the relationship of the density of the cone patterns on the light-guide to the distance from the light input of the back light unit in Fig. 3;

Fig. 5 is a view for explaining the cone pattern density at specific areas of the light-guide plate in the back light unit in Fig. 3;

Fig. 6 is a detailed perspective view of the light-guide plate in Fig. 3;

Fig. 7 is a graph illustrating a distribution of intensity from light exiting from the light-guide plate in Fig. 3; and

Figs. 8A and 8B are section views showing alternative examples of the light path converter in Fig. 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A back light unit according to an embodiment of the present invention is shown in Fig. 3. The back light unit includes a light-guide plate 34 including a cone pattern 34a. The cone pattern 34a uniformly distributes light from a light input 50. The cone pattern 34a can be distributed either on an upper surface or a lower surface of the light-guide plate 34.

A reflective plate 32, disposed under the light-guide plate 34, reflects light from the light input 50 in an upward direction. A light-path converter 36 controls the light such that it enters perpendicularly to a surface of a liquid crystal display panel (not shown). Finally, a diffusion sheet 38 diffuses the light passing through the light-path converter 36.

Figs. 4A and 4B explain the relationship of the density of cones in the cone pattern 34a to a distribution of light. On the light-guide plate 34, as the distance from the light source increases, the density of the cones of the cone pattern 34a increases. Stated another way, spacing between cones decreases as the distance from the lamp input 50 increases. Such spacing allows the light exiting the light-guide plate 34 to be uniformly distributed, which is desirable.

The spacing of the cones can be modified to solve another problem. Fig. 5 is a view showing a surface of the light-guide plate 34 and the lamp 44. As shown, it is seen that the lamp 44 includes rubber packing 60. The rubber packing 60 allows the lamp 44 to be secured within the lamp housing 46. Unfortunately, the rubber packing 60 also screens parts of the lamp 44 resulting in partially dark areas of the light-guide plate 34. By more densely packing the cones in these areas, the overall uniformity of light being transmitted to the liquid crystal panel is enhanced.

The cones of the cone pattern 34a as shown in Fig. 6 have a diameter of about 100 to about 500 μm and a height of about 50 to about 900 μm. The height of the cones depends on a vertical angle θ' of each cone (see Fig. 3). The vertical θ' ranges from about 30° to about 120°. The output angle θ of a light exiting from the light-guide plate 34 can be raised to a maximum of about 35° by a combination of the light-guide plate 34 provided with the cone pattern 34a, the light input 50 and the reflective plate 32.

Fig. 7 illustrates distribution graph of light intensity to the output angle θ of a light exiting from the light-guide plate 34 when the vertical angle θ' of the cones in the cone pattern 34a is 45° and the diameter is 500μm. It is seen that intensity reaches a maximum value when the output angle θ is 35°. The output angle at which the intensity reaches maximum can be manipulated by adjusting the vertical angle θ' of the cones.

A light path converter 36 is placed above the light-guide plate 34 to direct the light to escape from the light-guide plate 34 perpendicularly to the surface of the liquid crystal display panel. In other words, the output angle θ of the light exiting from the light-guide plate 34 is converted.

A forward prism having a vertical angle θ'' ranging from about 90° to about 130° may be used as the light-path converter. Alternatively, one of prism sheets 40 and 42 as shown in Figs. 8A and 8B can be used as the light-path converter 36. Prism sheets 40 and 42 have an angle φ, called the between angle, arranged in a backward direction.

Wherein the between angle φ of the prism sheet 40 and 42 should be within 45°. Vertical angles θ'' of the prism sheet 40 and 42 can require optical angles of more than about 90°. Specially, the vertical angles θ'' of the prism sheet 40 and 42 prefers to have optical angles of above about 100°. With such optical angles, the bright lines of the lamp and the wall surface reflection phenomenon can be considerably reduced or eliminated when compared to using a prism sheet having a relatively acute optical angle from about 60° to about 70°.

Further, a hologram sheet may be used as the light-path converter 36. The hologram sheet converts light exiting from the light-guide plate 34 to be perpendicular to the liquid crystal panel without any dispersion. A pattern

provided on the hologram sheet as well as the shape of the hologram sheet convert the direction of the light exiting from the light-guide plate 34. The pattern and the shape can be manipulated to adjust for particular conditions.

Above prism sheet 40 or 42 (representing a light-path converter 36), the diffusion sheet 38 diffuses the light from the light-path converter 36 to the entire surface of the liquid crystal panel.

As described above, according to the present invention, only one light-path converter and only one diffusion sheet are needed. Also, a reflection of the light-guide pattern and wall surface as well as the bright lines of the light input are minimized. In addition, different types of sheets can be used as the light-path converter to improve the light efficiency as well as to reduce the manufacturing cost.

Although the present invention has been explained by the embodiments shown in the drawings described above, it should be understood to the ordinary skilled person in the art that the invention is not limited to the embodiments, but rather that various changes or modifications thereof are possible without departing from the spirit of the invention. Accordingly, the scope of the invention shall be determined only by the appended claims and their equivalents.